

Wyoming State Capitol Building Restoration and Modernization

Level I / II Life Safety and Fire Protection Assessment

25 September 2013



Presentation Overview

- Project Overview
- Applicable Codes
- Non-Conformance Issues
- Evaluation Criteria
- Engineering Analysis
- Findings

Project Overview

- Level I / II Life Safety & Fire Protection Assessment
 - Identify matters of non-conformance with building and fire codes
- Identify strategies to achieve code conformance
 - Improve overall building fire safety
 - Respectful of the building's historic fabric

Applicable Codes

- Wyoming State Building and Fire Code
 - 2012 ICC International Building Code (IBC)
 - 2012 ICC International Existing Building Code (IEBC)
 - 2012 ICC International Fire Code (IFC)
- NFPA 914, *Code for Fire Protection of Historic Structures*, 2010 edition
 - IEBC and IBC do not provide a comprehensive method for assessing fire safety in historic structures
 - Framework for quantifying overall life safety and protecting property and heritage

Non-Compliance Issues

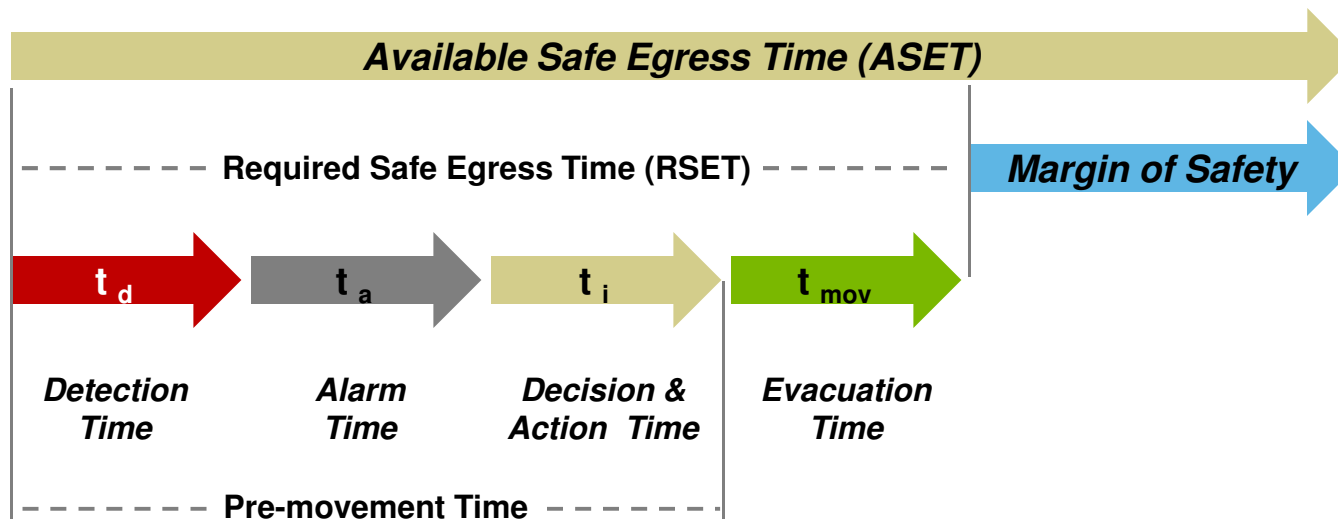
- Fire containment and building compartmentalization
- Combustible building construction materials in the attic spaces
- Fire suppression and control
- Means of egress
- Fire alarm
- Monumental stair handrails
- Rotunda guards
- Exit signage / way finding

Non-Compliance Issues: Focus Engineering Analysis

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- Exit signage / way finding

Evaluation Criteria

- Determine Required Safety Egress Time (RSET) in a fire emergency
- Determine Available Safety Egress Time (ASET) in a fire emergency
 - Time where tenable conditions can be maintained for safe occupant evacuation
- Life safety is achieved when ASET exceeds RSET



Evaluation Criteria: Fire Scenarios

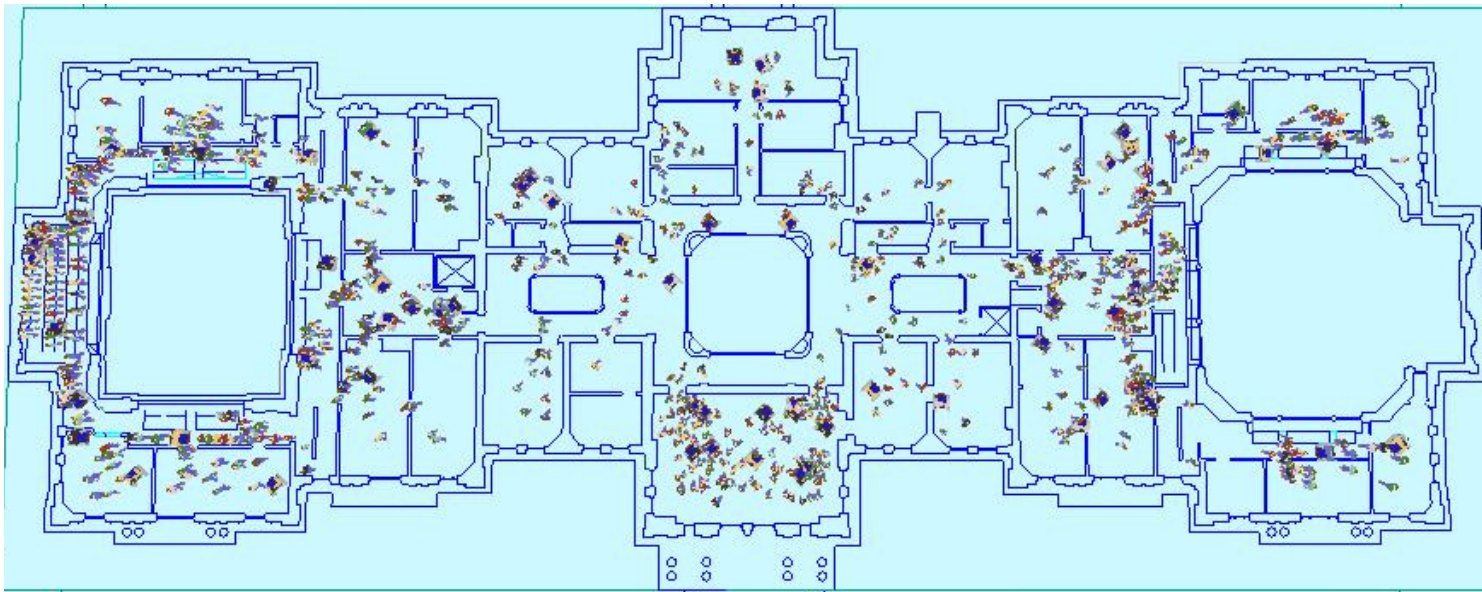
- NFPA 101 “Life Safety Code” Performance-Based Option was used to identify probable building fire scenarios
 - 1. Typical fire for the occupancy
 - 2. Ultrafast-developing fire that makes one of the exits impassable
 - 3. Fire in a normally unoccupied room
 - 4. Fire in a concealed wall/ceiling space adjacent to a large occupied room
 - 5. Slowly developing fire shielded from fire protection systems
 - 6. Most severe fire resulting from the largest possible fuel load
 - 7. Outside exposure fire
 - 8. Fire where the fire protection systems are rendered ineffective

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Engineering Analysis: RSET

- Computational evacuation modeling
 - Determine time required for building evacuation
- Analysis assumes building population 1,214 persons
 - Actual population is significantly less



Engineering Analysis: ASET

- Fire modeling analysis
 - Determine smoke spread, maintain safe conditions for evacuation
 - Evaluate protection strategies to mitigate fire hazard and fire risk



Findings

- Tenable conditions cannot be maintained in the existing building.
- Chambers' large occupant load causes queuing at the stairs on Floors 2 and 3 exposing the occupants to smoke spread from the chamber fire.
- Mechanical smoke control system is required to maintain tenable conditions for occupant evacuation.
- Open monumental stairs and Rotunda enhance smoke control.
- Christmas tree is the most severe fire.
- ASET exceeds RSET in all fire scenarios with enhanced fire protection systems except the Christmas tree scenario.

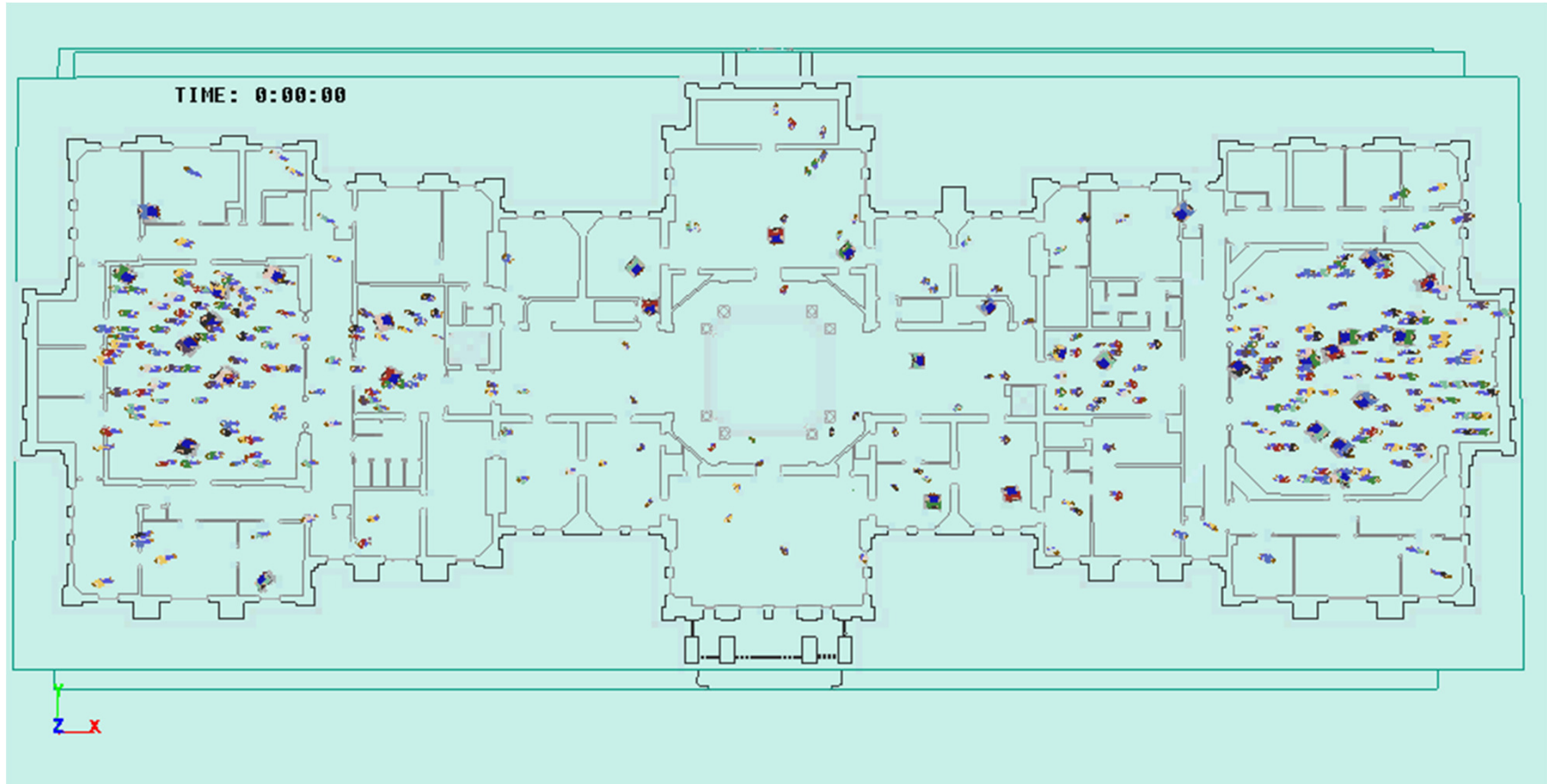
RSET – General Parameters

- The following slides reflect evacuation modeling results including written narrative followed by evacuation simulation video.
- General parameters for the simulations are as follows:
 - Simulations are not in real time.
 - Time is shown in BOLD at upper left of simulation
 - To play video click image on screen
 - Videos show evacuation time only, no delay is incorporated for pre-movement
 - Occupants are permitted to “choose” between any available exit.
 - Simulations are shown as examples of people movement; actual times and results vary based on scenario.

2nd Floor Evacuation – Two Stairs Available

- This simulation reflects evacuation from the second floor when all exits are available including both monumental stairs
- Observations from simulation are as follows:
 - Queuing is observed leaving the Chambers as early as 5 seconds into the simulation
 - Closest occupants reach monumental stairs within 10 seconds and queuing begins at stairs to exit floor
 - By 20 seconds, a large group of people has congregated at each of the stairs, as stair travel is a limiting factor in evacuation speeds
 - By 130 seconds (2 minutes), all occupants have reached the stair queues
 - By 190 seconds (3 minutes), one stair has cleared and occupants choose to leave their queue and travel to open stair
 - By 240 seconds (4 minutes), occupants have evacuated the second floor

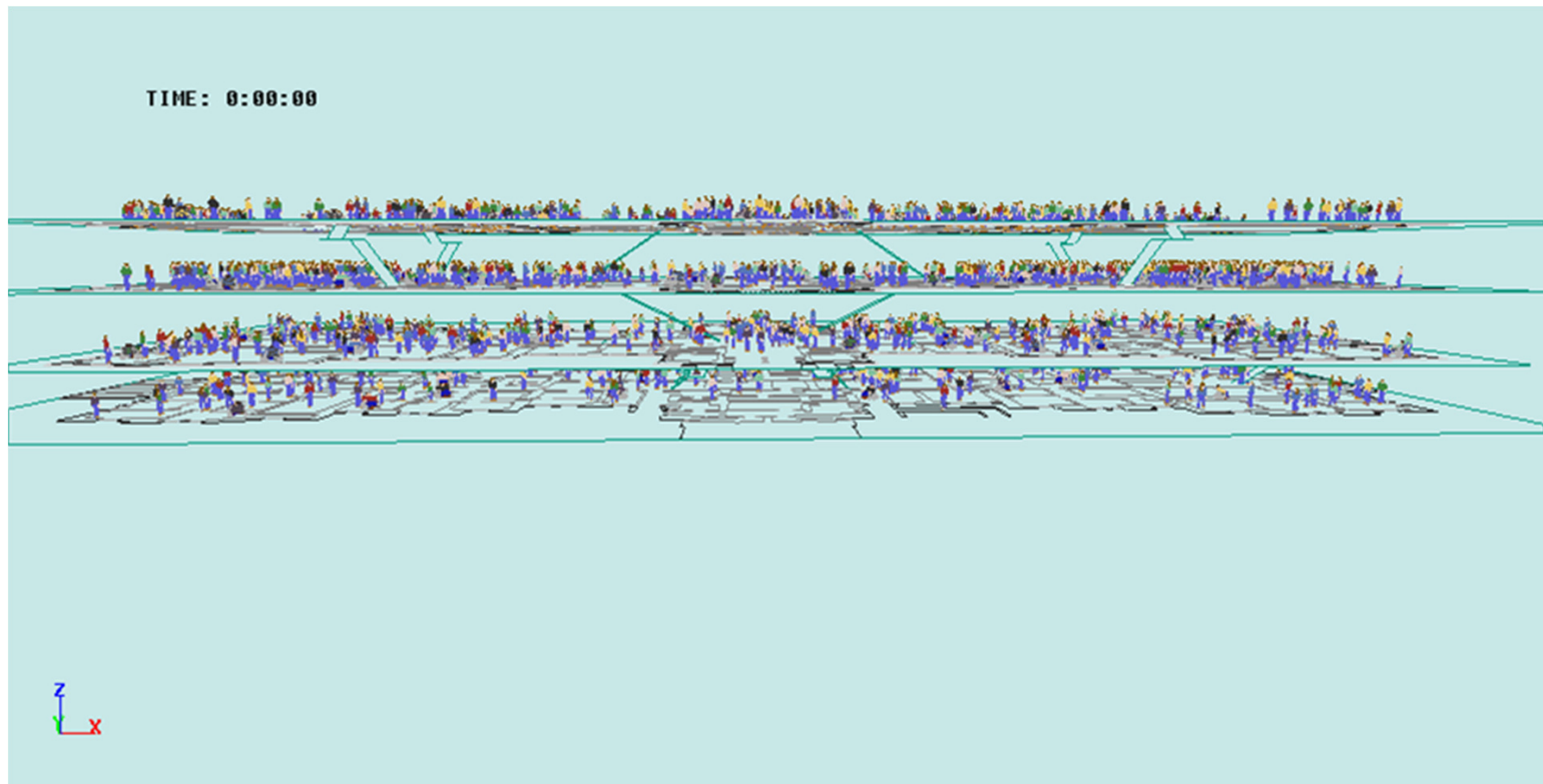
2nd Floor Evacuation – Two Stairs Available



All Floors Evacuation– Two Stairs Available

- This simulation shows a section of the building during evacuation when all exits are available.
- Observations from simulation are as follows:
 - Within 5 seconds, vertical travel down the stairs can be observed
 - Within 45 seconds, most occupants have reached an exit access stair queue
 - Within 60 seconds (1 minute) all basement occupants have left the floor
 - By 240 seconds (4 minutes) occupants have left the third floor and are congregated at exits from the second and first floors
 - By 420 seconds (7 minutes), occupants have left the second floor
 - By 450 seconds (7.5 minutes), all occupants have left the building

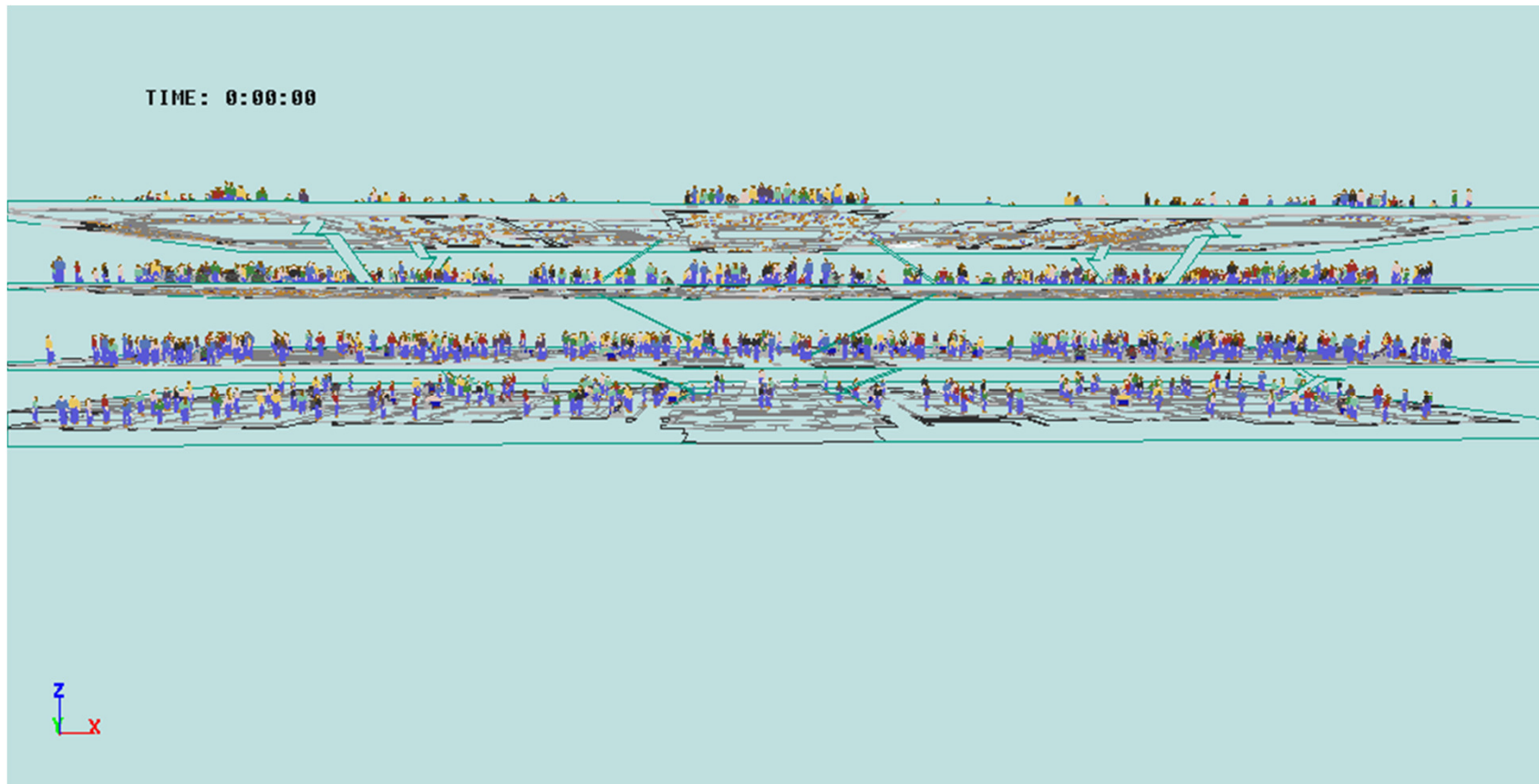
All Floors Evacuation – Two Stairs Available



All Floors Evacuation– One Stair Blocked

- This simulation shows a section of the building during evacuation when one stair from Level 2 to Level 1 is blocked.
- Observations from simulation are as follows:
 - Within 5 seconds, vertical travel down the stairs can be observed
 - Within 45 seconds, most occupants have reached an exit access stair queue
 - Within 60 seconds (1 minute) all basement occupants have left the floor
 - By 240 seconds (4 minutes) occupants have left the third floor and are congregated at exits from the second and first floors
 - Large groups of occupants are observed on the second floor as only one of the two stairs are available for egress.
 - By 420 seconds (7 minutes), occupants have left the second floor
 - By 450 seconds (7.5 minutes), all occupants have left the building

All Floors Evacuation – One Stair Blocked



ASET: General Parameters

- The following slides reflect fire modeling results including written narrative followed by modeling simulation video.
- General parameters for the simulations are as follows:
 - Simulations are not in real time – play is increased.
 - Time is shown at lower left in simulation
 - Fire starts at time = 0
 - Simulation runs 1200s (20 min)
 - To play video click image on screen
 - Scale at right hand side of simulation shows visibility in meters
 - Blue indicates high visibility – 30 m (100 ft) or greater
 - Red indicates low visibility – 10 m (30 ft) or less
 - Smoke exhaust, where presents, initiates at approximately 2 min

ASET: House Fire – No Smoke Control

- This simulation reflects the previously described design fire within the House Chambers with no Smoke Exhaust in building
- Observations are as follows:
- At 240s (4 min) smoke has spread into outer rooms into the corridor on the third floor
- At 360s (6 min) smoke has banked down within east portion of the corridor on the third floor is spilling into Rotunda
- At 460s (7.5 min) smoke has spread to west portion of the corridor
- By 720s (12 min) the smoke layer has descended within the Rotunda space to the corridors on the second floor
- By 780s (13 min) smoke has filled the third floor of the Senate Chamber
- By 1200s (20 min) smoke has spread throughout the remainder of the second floor

ASET: House Fire – No Smoke Control



ASET: House Fire –Smoke Control

- This simulation reflects the previously described design fire within the House Chambers with Smoke Exhaust in building
- Observations are as follows:
- At 320s (5.5 min) smoke has spread from the Chamber and outer rooms into the corridor on the third floor
- From 450s until 1140s (7.5 min to 19 min), smoke banks down to less than 6 feet above a portion of the east corridor intermittently. No other smoke spread is experienced.
- With smoke exhaust, smoke is contained to the area of origin (House chambers) and immediate surrounding spaces with little to no impact on means of egress for other building occupants

ASET: House Fire –Smoke Control



ASET: Stair Fire – No Smoke Control

- This simulation reflects the previously described design fire at the base of the stair with no Smoke Exhaust in building
- Observations are as follows:
 - At 90s (1.5 min) smoke has spread from the stair throughout east portion of the corridors and Rotunda on the first through third levels.
 - At 180s (3 min) smoke has filled the Rotunda and adjacent corridors on the second and third floors
 - At 240s (4 min) smoke has spread through the ante rooms and enters the Senate and House Chambers on the third floor
 - By 390s (6.5 min) smoke has descended to corridors on the first floor
 - By 930s (15.5 min) smoke has spread throughout the first floor and descended within both Chambers to the second floor

ASET: Stair Fire – No Smoke Control



ASET: Stair Fire – No Smoke Control

- This simulation reflects the previously described design fire at the base of the stair with Smoke Exhaust in building
- Observations are as follows:
 - At 180s (3 min) smoke has spread through the third floor within the Rotunda and portions of the first floor on the east side of the Rotunda
 - At 270s (4.5 min) smoke has been exhausted from the majority of the third floor, increasing visibility conditions to greater than 30 feet.
 - From 270s to 690s (4.5 min to 11.5 min) visibility conditions fluctuate within area of origin. Portions of second and first floor have visibility conditions less than 30 feet intermittently. Other portions of building remain clear.
 - After 690s (11.5 min) visibility greater than 30 feet is constant throughout the building. Smoke is shown at the fire, but is quickly exhausted from the space and does not spread to any other portion of the building.

ASET: Stair Fire – Smoke Control



Moving Forward

- Acceptance of Approach
 - NFPA 914 strategy
 - Performance-based analysis for determining tenability
 - Design fire scenario selection
 - Modeling tools
- Further refinement of results
 - Exhaust locations and capacities
 - Make-up air locations
 - Occupant load calculations